The Outlook for Continuous Casting in the Soviet Steel Industry

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An Intelligence Assessment

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SOV 83-10080
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Key Judgments

Information available as of 1 May 1983 was used in this report.

The USSR has lagged far behind the industrialized West in the use of continuous casting, a process that saves energy and labor and increases the efficiency of steelmaking. In 1980 about 11 percent of the steel produced in the USSR was continuously cast, compared with about 59 percent in Japan, 46 percent in West Germany, and about 20 percent in the United States.

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The USSR has been slow to adopt continuous casting because it has consistently given investment priority to projects that would boost crude steel production. Moreover, the Soviets are likely to keep obsolete open-hearth furnaces on line longer than originally planned because the open-hearth furnace can operate flexibly with any combination of pig iron or scrap metal. These furnaces, however, are rarely used in tandem with a continuous caster.

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The future installation of continuous casting capacity, therefore, hinges on Soviet ability to install more modern basic oxygen or electric furnaces. But as long as raw material shortages persist, they will limit the pace at which the Soviets can install the more modern steelmaking furnaces.

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The 11th Five-Year Plan calls for production of continuously cast steel to increase to 36 million tons by 1985, 20 million tons more than in 1980. We consider this goal unrealistic. To achieve it, the Soviets would have to install more than twice as much capacity during the period 1981-85 as they did between 1965 and 1980. If new construction continues at the 1981-82 pace, the Soviets will add no more than 7.5 million tons of new steelmaking capacity by 1985, and only a fraction of this will be equipped with continuous casters. We believe that production of continuously cast steel will not reach 36 million tons until 1990 at the earliest.

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We calculate that if the Soviets replaced 20 million tons of obsolete steelmaking capacity with modern steel furnaces equipped with continuous casters they could:

- Save 5 to 10 million tons per annum of standard fuel—that is, 3 to 6 percent of total fuel consumption in the industry in 1980.

- Reduce their labor requirement by perhaps 25,000 to 50,000 workers—about 2 to 4 percent of the steelworkers in 1980.

- Improve steelmaking efficiency. The Soviets could reasonably expect to obtain 19 million tons of semifinished steel products from 20 million tons of continuously cast steel. In the older, currently predominant ingot casting process, only about 15 million tons of semifinished steel products can be obtained from 20 million tons of steel. [redacted] 25X1

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Introduction

This paper assesses Soviet plans to increase the use of continuous casting in the steel industry, a process widely used in the industrialized West and one that saves energy and labor and increases both the efficiency of the steelmaking process and the quality of products.[1] The Soviets are counting on increased development of continuous casting to modernize the steel industry during the 1980s. This report describes the continuous casting process and its benefits, reviews the progress the Soviets have made in adopting continuous casting, compares present Soviet capacity with that of other major steel producers, and assesses Soviet plans for the increased use of continuous casting during the 1980s.

Background

The USSR is the world's largest steel producer. Soviet production of 147 million tons of crude steel in 1982 approached the combined output of 165 million tons posted by Japan and the United States—the world's second- and third-largest steel producers. Despite its great size, the Soviet steel industry has become a major drag on the economy. Planned cutbacks in the growth of new fixed investment stem in large part from the lack of steel to support construction and the manufacture of producer durables.

Because of shortages of iron ore, coking coal, and scrap metal, Soviet steel production has stagnated with 1982 output more than 5 million tons short of the 1978 peak level of about 152 million tons.

The current Five-Year Plan calls for production of crude steel and rolled steel products to increase to 169 million tons and 118 million tons, respectively, by 1985—roughly the same level originally planned for 1980. These goals are unrealistic; on the basis of our previous analysis of the raw material situation and Soviet investment policy, we estimate that in 1985 output of crude steel will be 155 million tons and rolled steel about 108 million tons.[2]

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The main cause of the deteriorating performance of the steel industry is inadequate past investment in all its sectors—from mining to rolling and finishing steel products. Investment allocations have not been enough to support ambitious development plans, partly because real investment costs are rising. Although the USSR plans to increase investment in the steel industry by almost one-third in the period 1981-85 compared with 1976-80, much of the increase will have to be channeled to the raw materials sector to forestall possible sharp drops in output.

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During the current Plan period, relatively less investment will be available for projects to expand capacity for finished steel or for modernization of steelmaking capacity, thus depriving the USSR of potential savings of raw materials, energy, and labor. A longstanding Soviet objective has been to replace most of the older open-hearth furnaces (OHFs) with basic oxygen furnaces (BOFs) and electric furnaces (EFs), which are predominant in the rest of the world. The Soviets have been planning to use continuous casters with these BOFs and EFs in order to realize the maximum benefits of continuous casting.

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The Continuous Casting Process

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To appreciate the benefits of continuous casting, it is necessary to understand the older steel production process called ingot casting. A simplified flow chart illustrates both processes (figure 1).

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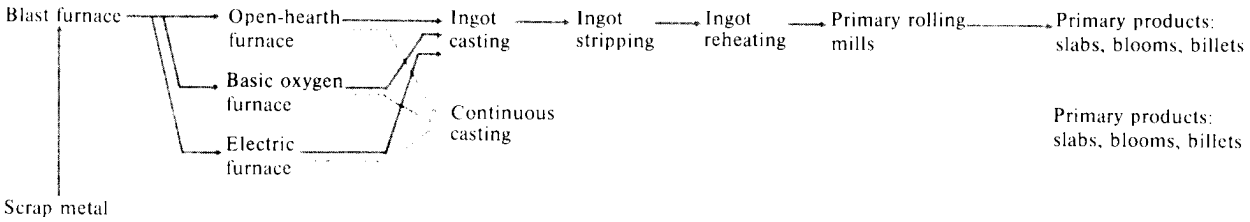
Figure 1
Simplified Ingot Casting and Continuous Casting Processes



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In ingot casting, the molten steel is poured from furnaces [3] into large rectangular molds. After the molten steel cools and solidifies, the ingots are mechanically pulled away (stripped) from the molds. The ingots are placed into soaking pits (reheat furnaces) to raise the temperature of the metal. Once the desired temperature is achieved, the ingots are rolled into primary shapes—slabs, blooms, and billets. The total time required to produce primary steel products is generally between seven and 10 hours.

In a continuous casting operation, molten steel is poured directly from the steel ladles into open-ended, water-cooled molds in which the molten steel solidifies from the outer, cooled surfaces and is cast directly into a slab, bloom, or billet (figure 2). These products can be further processed in secondary rolling mills or shipped directly as semifinished steel products. Although continuous casting can be used in tandem with any type of steel furnace, it is used almost exclusively in combination with BOFs or EFs. These furnaces produce molten steel in a fraction of the time required in the older OHFs. Moreover, in a BOF or EF the time required to produce molten steel can be calculated precisely; such precision does not exist with an OHF. Thus, a BOF or EF can better ensure a steady flow of molten steel into the continuous caster. As shown by Soviet and Western operating experience, the total time involved in the production of primary steel products (using a BOF or EF in tandem with continuous casting) is between 30 and 60 minutes.

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Soviet studies based on actual operating experience at continuous casting plants are consistent with the results of Western studies. For example, the Soviets report that:

- Energy requirements per ton of steel are reduced by 4 to 10 percent.
- Labor requirements per ton of steel are reduced by about 6 percent.
- The yield increases by 15 to 20 percent.[4]

[4] The yield is the ratio of the production of semifinished steel products to the production of crude steel. It is a basic indicator of the efficiency of any steelmaking process.

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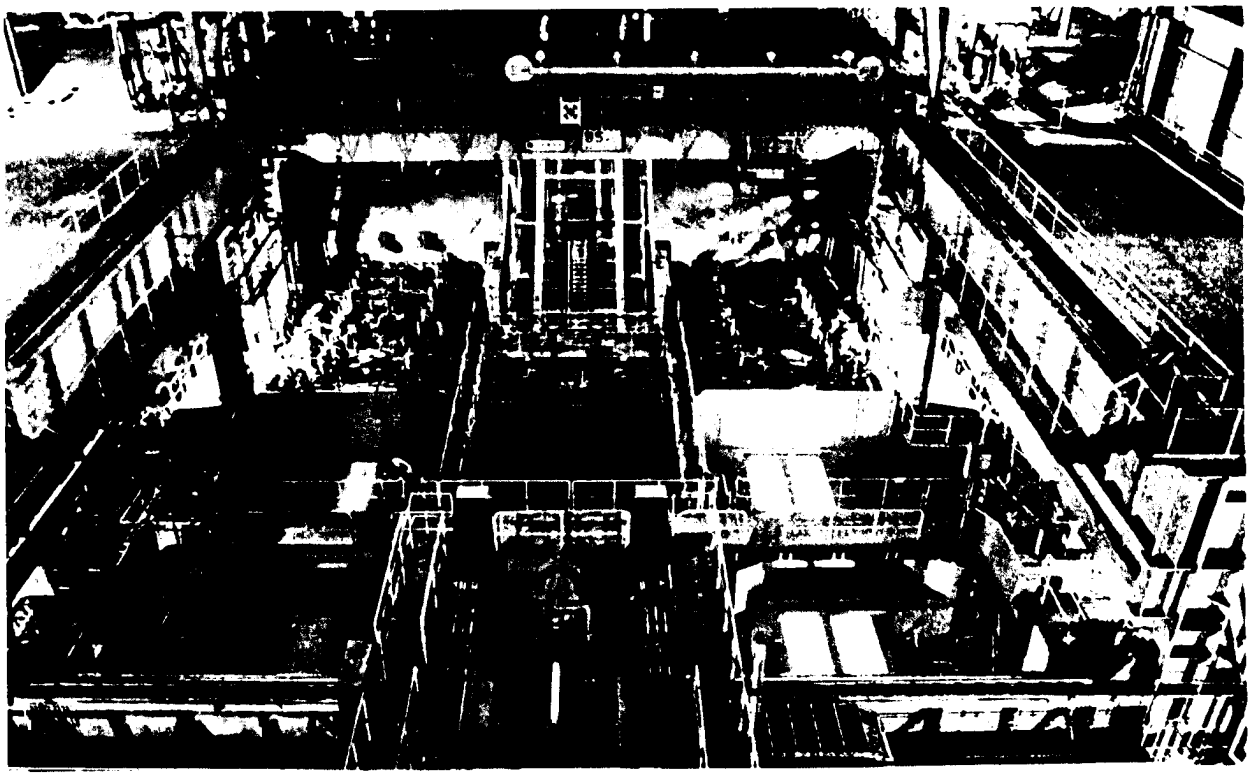
Figure 2
Continuous Casters in Operation



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- The quality of output improves. At ingot casting plants as much as 15 percent of the primary steel products are rejected because of flaws. At continuous casting plants the rejection rate is usually no more than 2 or 3 percent.

A study by the American Iron and Steel Institute shows results consistent with Soviet claims.

Soviet Development of the Continuous Casting Process

The USSR pioneered in the development of continuous casting. The Soviets installed the world's first pilot plants at Bezhitsii (Kuznets) and Serp i Molot (Moscow) in the late 1930s. They brought the first commercial plant into operation at Nova Tula in 1952—a decade ahead of the United States and Japan. They were the first to use continuous casting in tandem with BOFs and the first to develop a steelmaking plant based exclusively on continuous casting—the Novyy Lipetsk plant, the largest facility of its kind in the world.

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The USSR is one of the world's leaders in continuous casting technology. Many continuous casting machines in Western plants are based on original Soviet designs. Moreover, the Soviets have sold their equipment and technology to companies in over 30 countries, including the Nissan and Kobe Steel Companies (Japan) and the Terni Steel Plant (Italy).

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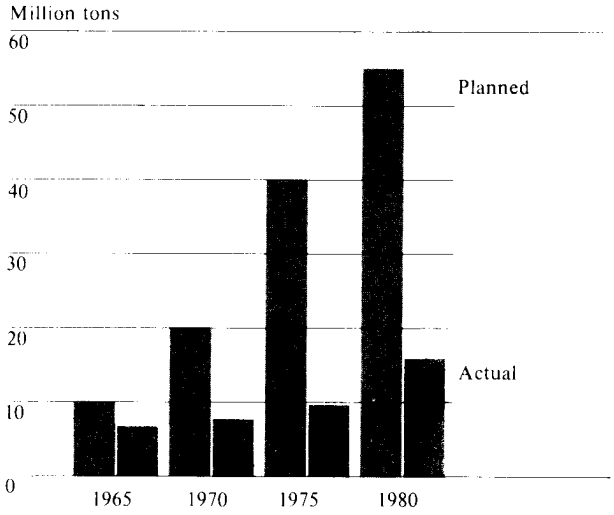
Figure 3
USSR: Planned and Actual Production of Continuously Cast Steel



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Despite its early dominance in the field and its high level of technology, the USSR has lagged behind the West in installing new continuous casting capacity. The Soviets have never come close to achieving their ambitious continuous casting plans. In 1962 the Academy of Sciences predicted that production of continuously cast steel would increase to 125 million tons by 1980 and account for about one-half of projected steel production in that year. Actual production reached only 16 million tons in 1980. *Pravda* reported that continuous casting would increase to 10 million tons by 1965; actual output that year reached 6.8 million tons. A 1964 article in *Ekonomicheskaya gazeta* reported that output would increase to 20 million tons by 1970 and 40 million tons by 1975; production actually was less than 8 and 10 million tons, respectively. The targets for the two Five-Year Plans of the 1970s called for output to increase by 15 million tons during each plan period. The total gain in production of continuously cast steel amounted to only 8.2 million tons during the entire 1971-80 period (figure 3).

The capacity of the USSR in 1980—16 million tons—is well below the levels achieved by other major producers—66 million tons in Japan and 20 million tons each in the United States and West Germany. In 1980 continuous casting accounted for about 11 percent of total Soviet steel production, while it accounted for about 59 percent in Japan, 46 percent in West Germany, and about 20 percent in the United States (table 1).[5]

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In 1980 the Soviets were operating 41 continuous casting machines installed at 18 steel plants (figure 4). The largest plant is located at Novyy Lipetsk. According to Soviet statements, all of the plant's output is continuously cast—roughly 8 million tons per year, one-half of total national production in 1980. The next largest facilities are the Azov and Zhdanov steel plants in the Ukraine and the Amur Steel Plant in East Siberia. All four plants account for about 75 percent of total Soviet continuous casting capacity (table 2).

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What Went Wrong?

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We believe that two decisive factors have limited the increased use of continuous casting in the Soviet steel industry. The Soviets have:

- Given little investment priority to modernization of the steel industry.
- Lagged in efforts to replace obsolete OHFs with BOFs and EFs. (As already noted, the maximum benefits of continuous casting are realized when it is used in combination with a BOF or EF.)

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[5] The US steel industry, like that of the USSR, has lagged behind Japan and Western Europe in the use of continuous casting. According to American experts, investment funds have been limited by the poor profitability of the industry. Meanwhile, the US steel industry has been forced to channel increasing amounts of scarce capital into a wide range of modernization projects, including new BOF and EF capacity and new blast furnaces. In the last decade an increasing share of investment has been devoted to expensive water and air pollution control equipment. Finally, continuous casting is used to its best advantage at large steel plants where the greatest economies of scale can be achieved. US plants tend to be smaller than foreign plants, especially those in Japan, thus reducing somewhat the potential benefits of continuous casting.

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Table 1
Continuously Cast Steel in Major Steel-Producing Countries, 1965-80 [a]

Thousand metric tons

	1965		1970		1975		1980	
	Continuously Cast Steel	Percent of Total Production	Continuously Cast Steel	Percent of Total Production	Continuously Cast Steel	Percent of Total Production	Continuously Cast Steel	Percent of Total Production
Japan	3,700	4	6,000	6	31,700	31	66,271	59
West Germany	3,150	9	6,000	13	9,700	24	20,162	46
United States	3,600	3	12,000	10	12,700	12	20,595	20
USSR	6,800	7	7,800	7	9,700	7	16,000	11
Italy	520	4	4,000	23	8,070	37	13,218	50

[a] Sources: *Metal Bulletin*, August 1982, p. 11; *Quarterly Bulletin of Steel Statistics for Europe, United Nations* (various issues); Office of Technology Assessment, US Congress, *Benefits of Increased Use of Continuous Casting* (October 1979), pp. 26-27.

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Despite rhetoric to the contrary, progress has been slow in reorienting investment priorities in favor of projects to modernize the steel industry. Although Soviet specialists have been urging a shift in investment priority for years, a Soviet study indicated that in the late 1970s about 90 percent of annual investment in the steel industry was earmarked for projects to boost crude steel production.

Because of the low investment priority given to modernization, the Soviets have been slow to replace obsolete OHFs. In 1980, for example, OHFs still accounted for about 60 percent of total steel production, much more than in other steel-producing countries. Moreover, only about one-fifth of the BOF and EF capacity installed since 1965 has been equipped with continuous casters. Soviet BOF and EF capacity rose by about 47 million tons from 1965 to 1980; continuous casting capacity rose by only 9.2 million tons during this period (figure 5). According to analysis by French industry specialists, only about 15 percent of Soviet BOF capacity was equipped with continuous casters in the late 1970s. If this assessment is reasonably correct, less than 7 million tons of total Soviet BOF capacity (44 million tons) are equipped with continuous casters. This unbalanced development stems primarily from the consistent emphasis that the Soviets have given to increasing crude steel production, including the need to allocate increasing amounts of investment resources to iron ore beneficiating facilities.

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Outlook

The goals of the 11th Five-Year Plan (1981-85) call for production of continuously cast steel to increase to about 36 million tons by 1985, an increase of 20 million tons compared with production in 1980.[6] The Soviets hope that continuous casting will account for about 20 percent of planned 1985 steel production of 169 million tons. We believe that Soviet plans are unrealistic. To achieve the plan for continuous casting, the Soviets would have to install more than twice as much capacity between 1981 and 1985 as they have been able to install between 1965 and 1980—an outcome we consider unlikely. We believe that Soviet production of continuously cast steel will not reach 35-37 million tons until 1990 at the earliest.

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[6] The 1985 target for continuously cast steel is 35-37 million tons.

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Figure 4
Major Continuous Casting Plants

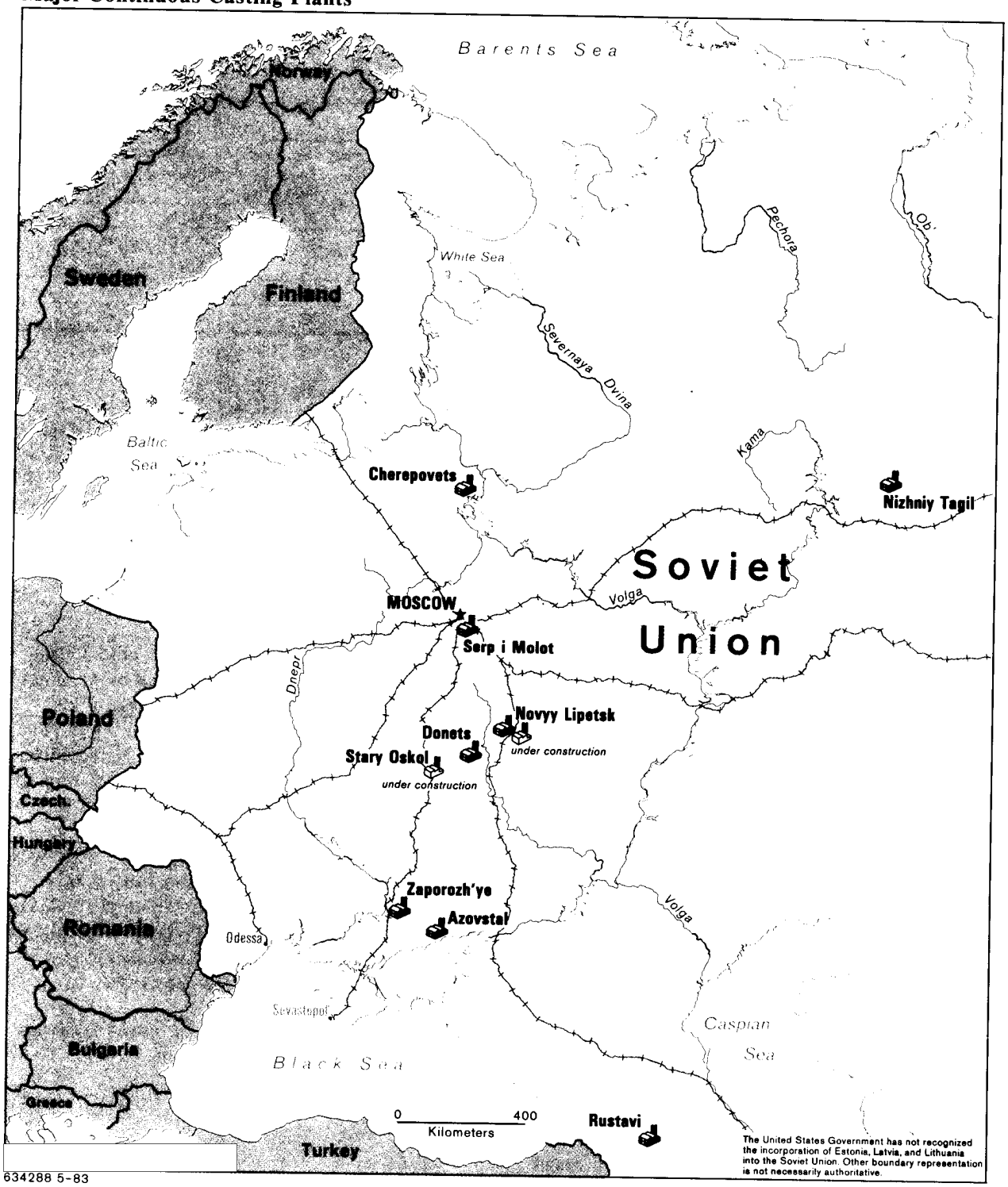

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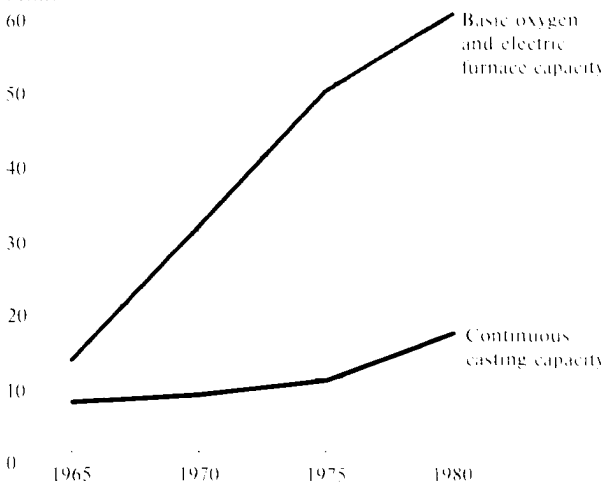
Table 2
USSR: Annual Capacity of Continuous Casting Plants [a]

Metric tons

Name	Annual Capacity	Startup Year
Amur Steel Works [b]	1,250,000	1967, 1972
Azov Steel Works	2,000,000	1975
Cherepovets	750,000	1970
Donets	600,000	1960
Zhdanov	1,300,000	1975
Gorkiy [b]	400,000	1955
Nizhniy Tagil	300,000	1968
Novyy Lipetsk [c]	8,000,000	1959, 1974
Liepaja	400,000	1967
Sibelektrostal	50,000	1966
Serp i Molot	100,000	1952
Rustavi	400,000	1966
Bekabad	300,000	1962
Nova Tula	250,000	1952

[a] Based primarily on *Continuous Casting Installations Worldwide 1982* (Green Brook, New Jersey: Institute for Iron and Steel Studies, 1982), pp. 79-80.
[b] Two plants.
[c] Three plants.

Figure 5
Cumulative Increases in Basic Oxygen Furnace, Electric Furnace, and Continuous Casting Capacity, 1965-80



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The Soviets probably intend to equip most of the BOFs and EFs scheduled to be installed during the 1981-85 period with continuous casters. Plans call for the completion of 12 million tons of BOF capacity and 11 million tons of EF capacity, roughly in line with the 20 million tons of continuous casting capacity slated for completion during this period. The Soviets seem to be counting on adding as much as 8-10 million tons of new continuous casting capacity at Novyy Lipetsk and Stary Oskol plants, which are being built with French and West German assistance. But these new plants are three to five years behind schedule. We have estimated that the Novyy Lipetsk plant will not be fully operational until 1987 at the earliest. The Soviets may be able to begin production at Stary Oskol in 1984, but it will take several years before this plant is fully operational. As recently as 1978, Moscow discussed plans to add 12 million tons of continuous casting capacity at the Krivoy Rog plant. But there is no evidence that the Soviets have started to work on this project. Because of the long leadtimes involved in constructing plants, even if work started now it would take at least a decade to complete the project.

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During 1981 and 1982 the Soviets added about 3 million tons of steelmaking capacity, mainly BOF capacity at Cherepovets and Chelyabinsk. We do not know how much, if any, of this new capacity was equipped with continuous casters. If the 1981-82 pace continues, the Soviets will add no more than 7.5 million tons of steelmaking capacity during 1981-85, about half of the increase achieved during 1976-80. Even if all of the new capacity were equipped with continuous casters, it would still represent only about one-third of the increase planned for the period 1981-85.

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The original plan implied that additions of continuous casting capacity would average about 4 million tons per year during 1981-85. The recently announced

plan for addition of new capacity in 1983 seems to reflect the Soviets' awareness that the original plan was unrealistic and that the goals have been scaled down. The Soviets plan to add about 1.1 million tons of new continuous casting capacity in 1983—750,000 tons at Stary Oskol and 350,000 tons at Orsk-Khalilovo. We doubt that even these less ambitious goals are attainable. As noted, work on the Stary Oskol plant is already years behind schedule, and it is doubtful that the plant will be even partially operational until 1984.

Potential Benefits

Various Soviet studies suggest that increased use of continuous casting would lower costs of steel production by about 20 rubles per ton if an OHF, ingot casting operation were replaced with a BOF, continuous casting combination. Savings would amount to roughly 8 rubles per ton if a BOF, ingot casting operation were replaced with a BOF, continuous casting combination. Depending on the type of steelmaking furnace to be replaced, annual savings could range between 160 and 400 million rubles if the Soviets would add 20 million tons of continuous casting capacity. Potential savings of 400 million rubles represent more than 10 percent of annual investment in the steel industry.

We can also estimate the energy and labor savings as well as the increased yield the Soviets would achieve if the plan for continuous casting were carried out. In the examples presented in the next section, we compare the benefits of a BOF or an EF operating in tandem with a continuous caster with an OHF operating with an ingot caster.

Energy. According to a detailed study by Western experts of fuel use in the Soviet steel industry, if OHFs were replaced with BOFs or EFs, fuel consumption per ton of product could be cut by 25 and 50 percent, respectively. Hypothetically, the Soviets could save as much as 5 million tons of standard fuel [7] per annum if they would replace 20 million tons of OHF capacity with BOF capacity. The savings could jump to 10 million tons of standard fuel per annum if the OHF capacity were phased out in favor of EF capacity. This represents about 3 to 6 percent of estimated energy consumption in the Soviet steel industry in 1980.

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These savings, however, are notional. Actual savings would be realized only if obsolete OHF capacity were retired and replaced with more energy-efficient equipment. Because of the lag in Soviet steel production and the growing evidence of steel shortages in the domestic economy, the Soviets will balk at retiring any steelmaking capacity (no matter how obsolete) for the foreseeable future. As already noted, as long as raw material shortages exist, the Soviets will be forced to rely heavily on OHFs which operate flexibly on pig iron or scrap metal. Therefore, continuous casting will only lower the increase in energy requirements in the steel industry—not reduce them.

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Increased Yield. A basic measure of the efficiency of steelmaking operations is the yield obtained in the production of rolled steel products. A longstanding Soviet objective has been to improve the yield to the level achieved in the West. In 1981 the Soviet yield was about 75 percent, a ratio that has not changed much since 1950; the yield in West Germany and Japan was about 85 and 87 percent, respectively. In other words, to obtain 1 ton of semifinished product the Soviets had to produce about 1.3 tons of crude steel, while the United States had to produce 1.2 tons and West Germany and Japan 1.15 tons.

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The Soviets report that a yield of about 95 percent is normally achieved at their continuous casting plants, a figure consistent with Western operating experience. If the Soviets were to add 20 million tons of new continuous casting capacity, they could reasonably expect to obtain about 19 million tons of semifinished steel products. On the other hand, ingot casting plants, with an average yield of 75 percent, could achieve an additional 19 million tons of semifinished steel products only by producing an additional 25 million tons of crude steel.

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[7] A ton of standard fuel is the energy equivalent of 5.1 barrels of oil or 844 cubic meters of natural gas.

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Labor Savings. According to estimates of the US Department of Commerce, approximately 1.4 million people worked in the Soviet steel industry in the late 1970s—roughly 4 percent of the industrial labor force. Of this total, the Soviets report that some 60 percent were engaged in mining and support activities and about 20 percent in rolling and finishing steel products. If these numbers are reasonably correct, they suggest that about 20 percent of the labor force (roughly 280,000 workers) are now engaged in the production of primary steel products. 25X1

The Soviets report that continuous casting can reduce labor requirements by about 6 percent (presumably in comparison with an OHF, ingot casting facility). We cannot estimate the number of workers that continuous casting could free for other uses with any degree of precision. Data are not available on the labor forces at ingot casting or continuous casting plants. Nevertheless, we believe that the number of workers who could actually be freed for other employment would be comparatively small—probably no more than 25,000 to 50,000 workers. 25X1

Like potential energy savings, any labor savings associated with continuous casting are notional. The most the Soviets can realistically expect is that additional continuous casting will lower the growth of labor requirements in the steel industry. Despite the comparatively small numbers of workers involved, the Soviets probably will nonetheless be giving higher priority to any labor-saving technology that will help them either to lower labor requirements or to reduce the rate of growth, given the sharp drop in the growth of the labor force that will occur during the 1980s. 25X1